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PROGRAM MANAGEMENT GUIDELINES FOR PRODUCIBILITY ENGINEERING AND PLANNING (PEP)

January 1985

Fred L. Adler
Donald G. Alducin
David V. Glass
Richard A. Gunkel

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LOGISTICS MANAGEMENT INSTITUTE
6400 Goldsboro Road
Bethesda, MD 20817-5886

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Weapon systems and equipment are not always designed for economical fabrication, assembly, inspection, and testing with available production techniques. As a result, deliveries are often late and costs exceed expectations. Production suffers because producibility is not considered early enough during design and because production planning during development is inadequate.

Because of concern with these problems, the Secretary of Defense has called upon DoD components to enhance design and development so as to smooth the transition to production. Among major changes in the acquisition process,

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DoD now requires planning for production from the beginning of the acquisition process. Before full-scale development can start, a comprehensive program of producibility engineering and planning (PEP) must specify tasks, define measurable goals, and provide for contractor accountability. The objectives of PEP are to make sure that the system being designed is in fact producible and to calculate how to produce it most efficiently.

We propose guidelines that will provide managers of weapons system programs with a practical approach to developing, executing and funding individual PEP programs.

To get the most out of PEP, we recommend that the program manager focus on producibility at the very start of the program and conduct a PEP program that balances design and producibility and incorporates demonstrations of advanced manufacturing processes. During full-scale development, he should carry out a PEP program that designs and demonstrates production tooling, facilities, and manufacturing methods.

We found that when requirements and funding are sound, such as in the F-16 and Air-Launched Cruise Missile programs, a good PEP program can smooth transition from development to production.

Executive Summary

PRODUCIBILITY ENGINEERING AND PLANNING (PEP): PROGRAM MANAGEMENT GUIDELINES

Weapon systems and equipment are not always designed for economical fabrication, assembly, inspection, and testing with available production techniques. As a result, deliveries are often late and costs exceed expectations. Production suffers because producibility is not considered early enough during design and because production planning during development is inadequate.

Because of concern with these problems, the Secretary of Defense has called upon Department of Defense (DoD) components to enhance design and development so as to smooth the transition to production. Among major changes in the acquisition process, DoD now requires planning for production from the beginning of the acquisition process. Before full-scale development can start, a comprehensive program of producibility engineering and planning (PEP) must specify tasks, define measurable goals, and provide for contractor accountability. The objectives of PEP are to make sure that the system being designed is in fact producible and to decide how to produce it most efficiently.

We propose guidelines that will provide the managers of weapon system programs with a practical approach to developing and executing individual PEP programs. The guidelines are drawn from an examination of weapon system programs, two of which made a successful transition from development to production -- the F-16 and the Air-Launched Cruise Missle (ALCM).

To get the most out of PEP, the program manager should:

- Focus the attention of design engineers and production engineers on producibility from the very start of the program.

- Give careful consideration to producibility in acquisition strategy, especially with respect to manufacturing processes, production targets, costs, contracting approaches, and competitive factors.

- In RFPs, require specific PEP responses by contractors and assign heavy weight to producibility when choosing sources. Once a contract is in effect, monitor the contractor's PEP performance.

- During both concept formulation and the demonstration and validation phases, conduct a PEP program that balances design and producibility and incorporates demonstrations of advanced manufacturing processes.

- To demonstrate readiness for production, prepare essential components of the production plan before deciding to go into full-scale development. Include them as explicit factors in source selection.

- During full-scale development, carry out a PEP program that designs and demonstrates production tooling, facilities, and manufacturing methods.

When requirements and funding are sound, a good PEP program can smooth the transition from development to production. Production will then be more efficient, costs will be kept within bounds, and the product will be better equipped for its mission.

TABLE OF CONTENTS

1. INTRODUCTION

Acquisition of a weapon system goes through five stages: design, development, test, production, and support. To acquire a producible weapon system requires a design that can be executed within affordability and design-to-cost limits. Throughout acquisition, therefore, producibility and related manufacturing considerations must be interwoven with design as part of a program of producibility engineering and planning (PEP) that assures both feasibility of production and production at least cost.

TRANSITION TO PRODUCTION

For many sophisticated weapon systems, manufacturing the items on time and within cost goals during the early stages of production has proved to be as difficult as developing weapons that meet their performance requirements. Cost growth (increases on the order of 50 percent are not unusual) and late deliveries stemming from production problems have consistently impeded attempts to field new equipment. The additional time and money needed to produce the desired quantities of weapons routinely frustrate the budgeting and planning process.

These production problems are evidenced in the factory by excessive levels of scrap and rework. Scrap means wasted materials. Rework means the unscheduled and usually manual machining of parts to meet specifications. The reasons for both are inadequacies of design, technical data, and production processes. Taken together, scrap and rework make up what is often termed the "hidden factory," which is cited in many studies of the production process as a source of increases in costs and delays in deliveries.

Some of the rationale for PEP can be found in a recent report of the General Accounting Office (GAO) in which they reviewed six weapon systems in depth, two from each Military Department, to illuminate some causes of early production problems and to outline actions that could help minimize such problems in future programs. GAO found that four systems ran into significant, unexpected problems in production. The main reasons included the technical demands and difficulties posed by the weapon systems, inadequate or inappropriate staffing, and a lack of stability of design, funding, and quantity. One may trace the principal causes of these production problems to the development phase, when the weapons were designed, a few experimental prototypes were built and tested, and design changes were made to correct deficiencies. The problems surfaced in the production phase, when quantity manufacture began.

In the development of the F-16 and Air-Launched Cruise Missile (ALCM), there was a more balanced treatment of near-term technical concerns and long-term production concerns resulting in a smoother transition to production than was true of other systems. Both programs experienced fewer technical difficulties than the other systems, and both were stable in funding and production quantities. For both systems, too, production-oriented program offices operated at the Service and contractor levels. Each program had the resources for substantial demonstration of production capabilities during development. Moreover, in these two programs, production readiness reviews -- formal examinations designed to find out whether a weapon is ready for production -- were held periodically during development. In the other systems, these reviews tended to be treated as one-time events late in development.

Another key feature of the F-16 and ALCM programs was that each had unusual characteristics that provided incentives to prepare effectively for

production. The goal of the F-16 program was to develop a low-cost fighter. This emphasis on cost enabled the prime contractor to avoid risky design features and to devote proper attention to production readiness. Furthermore, once the design was set, it remained stable because the four European countries participating in the program had individual veto power over any changes in design.

The ALCM enjoyed top national priority (defense priority-rated order DX-A1: Brickbat) when the B-1 bomber program was first canceled. Consequently, stress was placed on meeting the deployment schedule and achieving the peak production rate on time. This emphasis was strengthened by the ALCM's full-scale development competition, a competitive flyoff, which stressed demonstration of production capabilities as well as technical performance.

PEP BACKGROUND

To deal with the producibility problem, the Under Secretary of Defense for Research and Engineering (USDRE) asked the Defense Science Board (DSB) to recommend measures for improving and speeding the movement of weapon systems into production. The effort of the DSB focused on a small group of design, test, and manufacturing fundamentals, including key facilities and managerial issues that, according to the DSB, constituted the essential elements of low-risk programs.

In order to focus on making PEP a more effective part of the acquisition process, USDRE staff convened a joint DoD/industry conference in November 1982 which determined that PEP required greater management awareness and emphasis, dedicated funding, explicit contracting, early interface between design and production engineering, and better communication between government and industry. An action item to provide guidelines for constructing and

estimating the resources required to execute a comprehensive PEP program contained in this report was also identified.

In January 1984, DoD updated its statement of policy, procedures, and responsibilities for production management. DoD Directive 5000.34, "Defense Production Management," was replaced by DoD Directive 4245.6, "Defense Production Management." To ensure an orderly transition from development to cost-effective rate production, the new directive requires planning for production from the beginning of the acquisition process and better integration of production with other aspects of acquisition. It also requires a comprehensive PEP program be conducted throughout full-scale development (FSD) and that the PEP program include specific tasks, measurable goals, and a system of contractor accountability.

In January 1984, the Department of Defense (DoD) issued a new directive, number 4245.7, "Transition from Development to Production." The policies and procedures included in this directive and in other references[1] emphasize maintaining technical balance within the program despite possible changes in funding, scheduling, and other conditions. These policies and procedures are to be supplemented by a formal program of risk evaluation and reduction. The directive also authorizes development of a "transition manual" to aid in structuring technically sound programs.

All the Services have begun to adopt PEP programs. The Army, following up on previous staff studies, is instituting PEP throughout the Army Materiel Command under DARCOM Regulation 70-6, which states explicit PEP policy, procedures, and responsibilities, including procedures for PEP funding under the

[1]DoD Directive 5000.1, "Major Systems Acquisition," 29 March 1982; DoD Instruction 5000.2, "Major System Acquisition Procedures," 8 March 1983; DoD Directive 5000.3, "Test and Evaluation," 26 December 1979; and DoD Directive 4245.6, "Defense Production Management," 19 January 1984.

Army's research, development, test, and evaluation (RDTE) appropriation. The Air Force is carrying out PEP through its manufacturing management program under Air Force Regulation 800-9 and as part of its affordable-acquisition approach. The Navy's approach is reflected in the continued development of an instruction and a manual to define transition responsibilities.

OBJECTIVE AND ORGANIZATION OF THIS REPORT

The purpose of this report is to promote the planning, programming, administration, and execution of a successful PEP program by providing the program manager and his technical staff responsible for RDTE and production or manufacturing with a guide that:

- places PEP in its proper context, with emphasis on PEP early in the acquisition process;
- identifies the significant PEP activities at each phase of a weapon system's life cycle, tells how to carry them out, and specifies the resources needed;
- describes the effects of future computer technology on PEP.

This report recommends a series of steps for incorporating PEP into the acquisition process. Costs are also estimated; they will vary as a function of system producibility characteristics such as commodity type and degree of technological advancement. Experience with the ALCM suggests that PEP may take as much as 25 percent of RDTE funding during FSD.

2. PRODUCIBILITY ENGINEERING AND PLANNING (PEP) IN CONTEXT

WHAT IS PEP?

A simple definition of a PEP program for a weapon system is: designing producibility into a system so that production is feasible and optimizing production so that the system can be turned out at least cost.

The production feasibility of a given design depends not only on the characteristics of the design itself, but on the facilities available to produce it, the skill and experience of the contractor who will produce it, and the rate of production needed. The first objective of a PEP program is to so influence the design concept or chosen technical approach that production is feasible and the performance, cost, and schedule goals are met. That is producibility engineering.

The second objective is to optimize the production of the system. This includes influencing the design so that it can be produced efficiently, and planning and proving the production process itself. An example of increasing the efficiency of a design might be to use a precision casting rather than a machined part. Changing the factory layout to minimize materiel movement could be an example of a well-planned production effort. That is producibility planning.

A good PEP program should help the program manager make the necessary tradeoffs between performance and cost by explicating the production costs and risks associated with various designs. The program manager should also be enabled to set and meet cost goals.

Even a good PEP program is no panacea, however. In a program that has a weak foundation, many of the problems that appear to be matters of producibility in the transition to production are, in fact, symptoms of more

basic problems in the program's foundation. In an attempt to separate symptoms from causes, both the foundation of a program and the context in which the foundation places PEP must be considered.

PROGRAM FOUNDATION

A weapon system program is based on requirements, funding, and schedule. These elements are outlined below.

Requirements

The program for producing any weapon system must have well-documented and coordinated requirements, based on (1) a recognized need and a realistic threat assessment, and (2) a well-thought-out statement of mission and life cycle requirements that includes required quantities and inventory objectives over time. For the program to be stable, this requirement should have a broad base of support within the Service, Office of the Secretary of Defense (OSD), and Congress. Moreover, before any performance specifications are set, a thorough analysis should be made of alternative approaches to meeting the requirement. The program management will then have a solid understanding of what must be accomplished and what can be traded off in favor of cost or other goals.

Funding

The second basic element is funding. Approved funding must be available at a level consistent with the task at hand. Independent cost estimates must be prepared -- and prepared with the most accurate data available. Many studies of the acquisition process have concluded that over-optimistic budgeting at the outset of a program is a leading cause of cost growth. Too often, development is simply not finished before production because the program never included enough money to complete it.

Because of fast-paced technology, estimating costs is difficult. Pushing the state of the art to achieve performance may be necessary; if so,

it must also be funded. The same is true of manufacturing technology. If the design requires novel manufacturing techniques, the risk must be recognized and funded. A program that does not recognize these risks will have a weak foundation.

The acquisition strategy itself is also a factor in required funding levels and funding profiles. The amount and nature of the competition, the development schedule, and the production rates required must all be balanced against the funding that is realistically available to the program. All told, cost estimating and cost negotiations early in a program set the tone for program management.

Schedule

The third basic element in the program foundation is a program schedule that is consistent with the task at hand and the approved funding level. The development and production schedule must interact closely with funding levels and funding profiles.

In special cases, accelerated schedules may be warranted. Some possible causes are: rapid changes in the threat, new threat information, and a desire to move quickly to exploit a technical advantage.

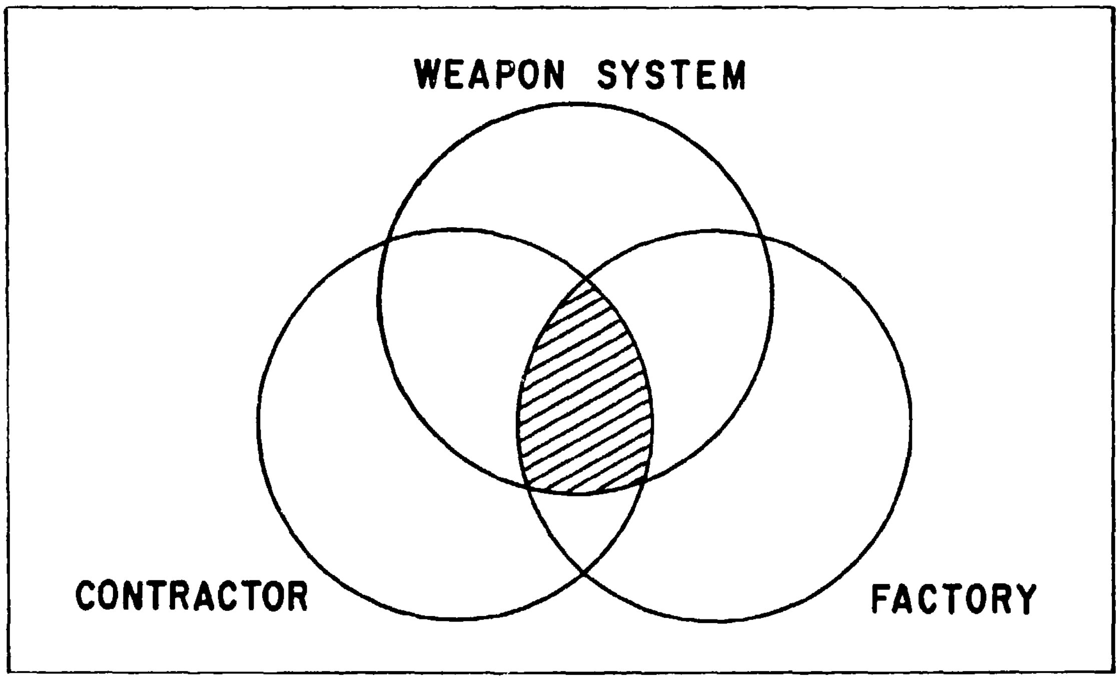
Often the schedule has served as a relief valve for a program that was under-funded because the magnitude of the task was not fully recognized or acknowledged or unpredictable problems were encountered.

Construction of a Foundation

Building a foundation for a producible system requires a thorough analysis and understanding of the three sets of characteristics shown in Figure 2-1. Important contractor characteristics include previous results with similar systems and technology, the contractor's track record in production, and the competitive situation. The factory characteristics relate to

plant and equipment, specifically: production capacity, production tooling and equipment (available or planned), and capabilities and plans for assembly, integration, and testing. Characteristics of a weapon system include the quantity to be produced, the planned production rates, and the complexity of the system.

FIGURE 2-1. PRODUCIBILITY CHARACTERISTICS



The reason the foundation is critical extends far beyond PEP, but the effect of a weak foundation can be clearly illustrated with PEP as an example. The argument is often heard that the reason for failure to carry out a PEP task is that the time and money were devoted entirely to preparing a design that met performance requirements and such other constraints as size and weight.

Yet the fact remains that we do not field designs -- we field manufactured products. If the requirement is inadequately defined or if not enough time or funding is available, the PEP tasks and procedures outlined in

DoD Directives 4245.6 and 4245.7 will not be properly executed. The result will be a system that does not make a smooth transition to production. This effect has been documented in many studies by the Services, GAO, and others. (See, for example, the Air Force Affordable Acquisition Approach, Army Staff Study, and the GAO report referenced in the Bibliography.) Even when a marginally acceptable system is fielded, program managers have lost opportunities to reduce costs, save time, manufacture more efficiently, and cope with production surge.

PEP IN CONTEXT

PEP must be understood in the context of the total program. It has a significant role to play, but it cannot be effective if the foundation is weak. If the problems of producibility result from weaknesses in the foundation, even a sound PEP program will not eliminate the underlying difficulty.

To be effective, PEP must be considered during every phase of weapon system acquisition. The following chapter discusses the tasks that make up a good PEP program in each phase and the measures that the program manager should take.

3. PRODUCIBILITY ENGINEERING AND PLANNING (PEP) ACTIVITIES

INTRODUCTION

The overall objective of PEP is to make sure that producibility of the weapon system is an integral part of the design process. The importance of producibility to the Government should be made manifest in the source-selection process. Accordingly, the program manager should: devise an acquisition strategy that is producibility-oriented, write Requests for Proposals (RFPs) that state clearly the PEP program required, weight the evaluation criteria to reflect the importance of PEP, and review and follow up contractor performance.

A description of how this might be done at each phase of the acquisition cycle follows, along with a table of PEP activities for each phase. This description and the suggested PEP activities can be treated as general guidelines. Though they have been developed on the basis of experience, especially with the ALCM, every individual program requires careful tailoring of the guidelines to reflect its own realities.

CONCEPT EXPLORATION

The prime objective of the program manager in this phase is to achieve a design concept or select a best technical approach. He should also consider production feasibility in the design process. For production feasibility to be considered, manufacturing and producibility engineers must take part in the design process from the start. To make this happen, the program manager must make clear what the contractors must do and state specifically the weight assigned to producibility in source selection for subsequent phases. A number of PEP tasks can be initiated during this phase, especially producibility

studies and analyses and identification of manufacturing technology (MANTECH) projects and applications, as well as some preliminary planning for manufacturing, facilities, product and quality assurance, and make-or-buy decisions.

Effort by the Program Manager

The program manager's effort in this phase centers on devising an acquisition strategy that assigns a major role to producibility, writing an RFP that requires a preliminary PEP plan from the contractor, evaluating the response to the RFP and the adequacy of the PEP plan, and evaluating the contractor's performance.

The RFP should require an explicit PEP response and should weight it heavily during source selection. When contracts were awarded for building the ALCM, the weight was about 25 percent. A clear Statement of Work (SOW) should be included in the RFP, along with a Contract Data Requirements List (CDRL) that calls for specific Data Item Descriptions (DIDs) for producibility tradeoff studies (i.e., studies that weigh tradeoffs between performance and producibility or between manufacturing alternatives). (Samples of producibility DIDs are displayed in the Appendix.)

In evaluating the contractor's responses, the program manager should focus on whether the contractor is proposing a sensible organization for his PEP effort (i.e., one that can successfully integrate producibility and design characteristics) as well as the nature of the producibility tradeoff studies to be conducted. He should evaluate the contractor's past performance and examples of prior producibility efforts. An element of the source-selection evaluation board (SSEB) should be established for this purpose.

During contract performance, the program manager should evaluate the producibility tradeoff studies, perform incremental reviews to determine the

production feasibility of the design concept,[1] and evaluate the contractor's analysis of the need for MANTECH projects. At the end of this phase, the program manager should report his initial PEP activities to the Defense Systems Acquisition Review Council (DSARC) or Service equivalent and should be especially prepared to review the ten producibility tradeoff studies with the greatest cost impact.

Resources Required

After determining the number of people needed for the tasks outlined above, the program manager should assess the capability of his personnel and, if necessary, request additional funds for a larger staff or contract out some of the activities.

Experience with the ALCM program suggests that about 10 percent of the engineers in the program should have producibility or manufacturing as their main assignment. The costs of the PEP actions required of the contractor in this phase, principally producibility tradeoff studies, will be an integral part of the program.

DEMONSTRATION AND VALIDATION

The object of this phase is to demonstrate that manufacturing the end item is feasible. The tasks implied are much the same as in concept exploration. The major new activity is participating in preliminary design review, in addition to conducting periodic reviews of producibility. Principal PEP tasks, again, include producibility studies and analyses and manufacturing technology projects and applications. In addition, manufacturing planning translates engineering drawings and requirements into manufacturing process specifications and instructions. Facilities planning develops contractor

[1]See, for example, the producibility analysis checklist in DoD Manufacturing Management Handbook for Program Managers (Chapter 8), Defense System Management College, July 1984.

capital investment plans, identifies Government facilities and funding needed, and begins to develop a detailed production plan that includes facilities, tooling, and test equipment resources. Make-or-buy decisions are analyzed, and a contractor plan is developed. And product and quality assurance planning develops a program plan to improve the quality of the product.

Effort by the Program Manager

In this phase the program manager should update the acquisition strategy, program plan, and PEP schedule to reflect the results of the PEP program to date and the progress of the program.

The RFP for this phase should include a requirement for a proof-of-manufacture model plan in addition to continuation of the producibility tradeoff studies required in concept exploration. Again, the program manager should evaluate the proposals and monitor contract performance. An additional requirement is participation in the preliminary design review that will establish the system requirements and schedule for the FSD phase. As with concept exploration, the program manager should be prepared to report to the DSARC or Service equivalent on the top ten producibility tradeoff studies and the results of PEP. Activities suggested for this phase are listed in Table 3-1. The new activity is marked with an asterisk.

Resources Required

The resources needed in this phase are, again, determined by the activities conducted. For the program manager, a higher level of activity in evaluating contractor performance will be needed. Again, outside contractual assistance may be required.

Producibility engineers will remain at about 10 percent of engineering staff. In addition, some actual models of end items or their components and some early prototype tooling may be built or bought. Major commitments of resources are not needed, however.

TABLE 3-1. DEMONSTRATION AND VALIDATION

BEFORE RFP	RFP	EVALUATION OF PROPOSAL
Update acquisition strategy: - Require submission of a PEP plan as a separate part of the proposal. - In source-selection criteria, assign specific weight to PEP proposal. Update program management plan. Update PEP schedule. Establish Source Selection Evaluation Board (SSEB) and criteria. Assign people to evaluate PEP proposal.	Update Statement of Work (SOW) for PEP program. Require explicit PEP proposal. Require formal studies of producibility tradeoffs on all critical components in the Contract Data Requirements List (CDRL). Require component mockups, "proof-of-manufacture" models, and computer simulation models.	Determine contractor's responsiveness to PEP requirement: - Formal PEP organization. - Format of producibility tradeoff studies (examples from prior programs). - Identification of candidates for producibility tradeoff studies. - Schedule of producibility tradeoff studies. Review make-or-buy plan. Evaluate manufacturing risks, processes, materials, and technology. Evaluate past performance of contractor. Conduct site survey to evaluate industrial resources. Evaluate alternatives considered for proposed design. Evaluate adequacy of level of effort for PEP program.

CONTRACT PERFORMANCE	PRODUCIBILITY REVIEW	DSARC (OR SERVICE EQUIVALENT)
Require contractor to submit, for approval by program manager, an updated PEP plan 120 days after contract approval. Evaluate contractor's CDRL of producibility tradeoff studies on a monthly basis. Review updated analysis of cost drivers. Update analysis of Manufacturing Technology (MANTECH) requirements. *Conduct a preliminary design review.	In reviews of incremental design producibility every six months, evaluate: - Simplicity of design. - Standardization of components. - Analysis of manufacturing process.	Report on top ten producibility tradeoff studies performed. Provide results of PEP cost-benefit analysis. Describe PEP program.

*New activity.

FULL-SCALE DEVELOPMENT (FSD)

In this phase the scope of the PEP effort expands to include efficiency of production as well as feasibility of production. The object is to define the production configuration baseline, develop a sound production plan, design and conduct proofing of production tooling and test equipment, begin development of numerical control (NC) tapes and related software, and make sure that producibility continues to be an objective in the design effort. Proofing of production tooling and test equipment includes setting up pilot production lines and manufacturing development items as needed to validate production processes.

During FSD, the tasks of manufacturing facilities, product, and quality-assurance planning, as well as make-or-buy decisions, should be continued, and the overall demonstration and proofing of manufacture and production capability should begin.

Effort by the Program Manager

A decision to go into FSD is a major step toward production. Therefore, a prime consideration in source selection for FSD should be the proposed effort for preparing the production plan. This effort should be assigned an explicit weight (as much as 25 percent or more) in source selection and should be included explicitly in evaluating the proposal for the production plan. The program manager should develop the criteria for evaluating the proposal and should assign people to evaluate it. The evaluation should determine the contractor's responsiveness to the RFP and his planned production capability.

The task of monitoring contract performance increases in this phase. To assess PEP and production readiness, a critical design review and incremental production readiness reviews (PRRs) should be conducted. Progress in achieving design to unit production cost (DTUPC) goals should be included.

The incremental PRRs should monitor progress toward full production capability as the contractors progress through this phase. In addition, a physical configuration audit (PCA) on the production configuration baseline and a functional configuration audit (FCA) should be performed, to assure the adequacy of test requirements. The PCA should subject designated configuration items to technical examination, to verify that the items "as built" conform to the technical data documentation that defines them. The technical data package (TDP) should be developed and validated during this phase. The FCA should examine test data to verify that configuration items function as specified. Finally, at the end of FSD, interchangeability of parts should be demonstrated, to show stability of the design configuration.

At the end of this phase, the program manager should present at the DSARC or Service equivalent the results of the audits and PRRs, a final assessment of production risk, the production plan, status of DTUPC, and plans for accomplishing cost reduction during production that include value engineering, component breakout for competition, and second-sourcing.

Table 3-2 summarizes the activities in this phase.

Resources Required

The resource requirements are substantially greater in this phase than in the earlier ones. The myriad details of production planning and the increasing purchase of actual production tooling and trial manufacturing of components are costly. The production function within the program office starts to evaluate the detailed production plan, with a consequent increase in personnel. Conducting the audits and PRRs required will also create a need for additional skilled personnel within the program office or for more support from outside contractors.

In this phase the contractor should devote significant RDTE funding to the continued involvement of producibility engineers in the design effort,

TABLE 3-2. FULL-SCALE DEVELOPMENT (FSD)

BEFORE RFP	RFP	EVALUATION OF PROPOSAL
Update acquisition strategy and program management plan: - Require submission of a production plan as separate part of the proposal. - In source selection, assign explicit weight (as much as 25%) to production plan. Develop a production-plan schedule. Establish Source Selection Evaluation Board (SSEB) and criteria. Assign people to evaluate production plan in proposal.	Develop Statement of Work (SOW) for production plan. Require explicit production plan in proposal. Require formal report of production analysis. Require contractor to prepare for reviews of incremental production readiness and critical design, audit of physical configuration, and interchangeability SOW requirements. Require submission of complete technical data package before end of FSD for approval by program manager.	Determine contractor's responsiveness to production plan SOW, including formal production organization. Evaluate: - Industrial resources. - Make-or-buy analysis. - Tooling/test equipment identification. - Product-assurance program. - Manufacturing management systems. - PEP tradeoff studies and results. - Subcontractor PEP programs. - Facilities layouts. - Manufacturing test flows. - Method improvements/manufacturing aids plans. - Industrial Modernization Incentives Program (IMIP). Evaluate: - Schedule for technical data package development. - Technology transfer plan.

CONTRACT PERFORMANCE	DSARC (OR SERVICE EQUIVALENT)
Conduct critical design review. Require contractor to submit production plan Contract Data Requirements List (CDRL) 120 days after contract approval and 30 days before each production readiness review. Conduct reviews of incremental production readiness (at least every 6 months) to assess PEP and production readiness. Require an interchangeability demonstration at end of FSD at end-item level. Review technology transfer to second source. Conduct: - Physical configuration audit on production configuration baseline. - Functional configuration audit per military standard. - Audit of adequacy of the technical data package.	Report status of: - Production configuration audit. - Interchangeability demonstration. - Validation of data package. - Production plan. - Results of production readiness reviews. - Summary of production risk assessment. - Design-to-unit production cost. - Plans for cost reduction during production.

the development of the production plan, and the purchase of prototype tooling and pilot production. This may amount to as much as 25 percent or more, if experience with ALCM can serve as a guide.

PRODUCTION

The objective in this phase is to produce the weapon system on time and within the budget. The industrial resources must therefore be in place and adequate to support manufacture at the rate needed. The principal tasks here are to complete plans for cost reduction during production and to complete any remaining PEP efforts such as demonstration and proofing of facilities and tooling, manufacturing methods, and production control, as soon as possible. This includes any refinements to NC tapes and completion of software development. Basically, it is essential to ensure integrity of manufacturing management systems, tooling, facilities and production control to reflect the status of work in process, the location of materials, and the accuracy of the controlling data. First-article checkout for proofing of facilities should be done before manufacturing begins.

Effort by the Program Manager

The program manager's effort in this phase depends on the circumstances of the competition for production. In this report, we assume the most favorable circumstances from the standpoint of producibility, namely, two or more competing contractors and a split production award, are to maintain competition through production.

Before RFP, the Government should update the acquisition strategy, program plans, and schedules. The portion of the proposal devoted to the production plan should be assigned an explicit weight when the production split between the competing contractors is decided. A weight of 25 percent or more may be appropriate. In the RFP every competing contractor should be

provided with the TDP developed in FSD, and an Industrial Modernization Incentives Program (IMIP) provision and a Value Engineering Change Proposal (VECP) clause should be included. Proposal evaluation should be concerned with the production plan and on the production tooling and test equipment as well as on the contractors' man-hour analysis of manufacturing.

During this phase, the program manager should monitor contractor performance by planning rate reviews. In addition, the contractors should demonstrate the interchangeability of multi-sourced hardware. An evaluation of the VECP should be made, along with continued monitoring of each contractor's efforts to improve production methods.

Resources Required

All the activities in this phase are procurement-funded. No additional funding should be needed for them beyond what would be required as a matter of course in a production program.

SUMMARY

Table 3-3 summarizes 11 main PEP tasks to be conducted in all phases of the acquisition process that have been described. The table suggests resource funding requirements based primarily on the ALCM program approach. Many of these tasks stretch over several phases of acquisition. They include three planning tasks (manufacturing planning, facilities planning, and product and quality assurance planning) and five management tasks (producibility studies and analyses, manufacturing technology projects and applications, TDP development and validation, make-or-buy decisions, and PRR administration).

They also include three major tasks that require significant resources and funding: (1) production tooling and test equipment design and substantiation; (2) development of NC tapes and software; and (3) demonstration and proofing of facilities, manufacturing methods, and production control.

TABLE 3-3. PRODUCIBILITY ENGINEERING AND PLANNING (PEP)

TASK OBJECTIVE	SPECIFIC OBJECTIVES AND PRODUCTS	WHEN OCCUR	ESTIMATED RESOURCE FUNDING REQUIRED
Producibility Studies and Analyses	Establish a disciplined program of studies of engineering producibility tradeoffs. Be prepared to report results of top ten tradeoff studies to DSARC.	Conceptual/ Validation phases	10% direct engineering hours.
Manufacturing Technology (MANTECH) Projects/Applications	Analyze product for improved manufacturing processes and equipment and implement formal Government-funded MANTECH program.	Conceptual/ Validation phases	Less than 1/2% of direct funding.
Manufacturing Planning	Translate engineering drawings and requirements into clear process specifications and manufacturing instructions. Prepare proof-of-manufacture model plan.	All	25% of direct manufacturing hours in Full-Scale Development (FSD).
Facilities Planning	Contractors should develop capital investment plans for each acquisition program and update them annually. Government facility should be identified and funded. Both should develop a detailed production plan, including resources (facilities, tooling, and test equipment required).	All	Capital investment by contractors. Government facility funding when necessary.
Technical Data Package (TDP) Development and Validation	Develop a complete engineering and manufacturing reprocurement data package, to be validated in a physical configuration audit at the conclusion of FSD.	All	Principal phase is FSD. Combines other task results.
Make-or-Buy Decisions	Contractor should analyze make-or-buy alternatives and develop make-or-buy plan before each phase and submit it to the program manager for approval.	All	None.
Product/Quality Assurance Planning	Contractor should develop plan for formal quality-assurance program and submit to the program manager. Contractor should update plan for each phase of the acquisition cycle.	All	10% of direct manufacturing hours.
Production Tooling and Test Equipment Design/Substantiation	Design tooling and test equipment to maximize efficiency of manufacturing. Tooling and test equipment should be proofed before rate production begins.	Full-Scale Development (FSD) phase	Approximately 15%-35% of total required funding in FSD.
Numerical Control (NC) Tapes/ Software Development	Program NC tapes as soon as design is frozen. Software for factory test equipment should translate design test requirements. Both NC tapes and test equipment software should be subjected to formal configuration control.	FSD/Production phases	5%-10% of total required funding, especially in FSD.
Demonstration and Proofing of Facilities/Tooling/Manufacturing Methods/Production Control	Ensure integrity in the manufacturing management systems, tooling, facilities, and production control and reflect correct status of work-in-process, material location, and accuracy of the controlling data. First-article checkout (before start of manufacture), i.e., proofing of facilities.	All	5% of direct manufacturing hours, especially in FSD/ Production
Production Readiness Review (PRR) Administration	Conduct a series (at least 3) incremental PRRs to evaluate the contractor's readiness to enter production.	FSD phase	<1% of direct manufacturing hours.

Experience with ALCM suggests that PEP may take as much as 25 percent of RDTE funding during FSD.

CONCLUSION

The thesis of this paper is that all this activity and these additional resources early in the program will pay off in production. The product will be producible as designed, and the production environment will be optimal for producing the item. The item can therefore be produced on time and within budget, which will in turn allow the program to achieve credibility -- and therefore stability -- with DoD and Congress. The diseconomies of wildly shifting production rates and resources will be prevented. Doing things right the first time pays off, both immediately and throughout the program.

The effectiveness of these activities depends heavily on the quality of the staffs on both sides: program manager and contractors. Producibility engineers must be brought into the design process, and their contributions must be incorporated into designs. One factor in evaluating contractors for suitability should be the quality of production engineers he can assign to the problem. Contractors who do not have them must plan to get or train them.

Our conclusion is that producible weapon systems can be designed and efficiently produced. It has been done before. The activities and tasks described in this chapter can help make this happen in future programs, if the people and resources are made available. Producibility problems that are caused by a fundamentally flawed foundation will not be solved by a PEP program. But, given a good foundation, a well-conceived and well-managed PEP program will yield a producible design, efficient production, and a weapon system that is available on time and in the quantities needed.

Chapter 4 discusses the implications of computer technology for improving producibility through computer-assisted design, engineering, and manufacturing.

4. APPLICATION OF COMPUTER TECHNOLOGY TO PRODUCIBILITY ENGINEERING AND PLANNING (PEP)

Computer technology has revolutionized design and manufacturing. Advanced work environments and new applications of computer technology in design and manufacturing engineering are being introduced throughout industry, with dramatic effects on the activities that make up PEP. This infusion of advanced computer technology, if properly exploited, will result in more producible parts and hardware and will compress the acquisition process.

The advent of new computer-based design and manufacturing technologies will allow program managers to encourage contractors to make full use of computer-aided design/computer-aided manufacturing (CAD/CAM) and computer-integrated manufacturing (CIM) processes in the development of new systems. They are described below in terms of their effects on PEP.

COMPUTER-AIDED DESIGN/COMPUTER-AIDED MANUFACTURING (CAD/CAM)

The program manager should encourage the application of CAD/CAM to emerging systems. He should allow sufficient time to exploit available technologies before firmly establishing design and production parameters. The initial computer graphics will enable engineers to do without full-scale manufacturing mockups and to see how various components fit together much sooner than with previous programs. Early application of CAD/ CAM will allow automatic checks for design producibility, reduce the number and extent of engineering changes, reduce the expense of producing mockups, and establish a digital data base for engineering and manufacturing so that CAM can begin early in weapon system development. This will be made possible by:

- Many automatic tools, such as rule checking, where engineering rules, procedures, or both are checked for consistency as the designer proceeds, and others such as those for listing and checking parts against

specified criteria (e.g., reliability), assessing compatibility with other components, and searching for and retrieving previous designs that might prove useful in the current design.

- Routines that capture data from the design and that can then be used for assessing the design as well as for building data bases for estimating the types and amounts of materials that will be used to build the system, for developing the technical data package, and for programming numerical control machinery.

- Matching techniques that provide the ability to check the design against currently available manufacturing equipment, including the ability to check tool-path clearance and range and design tolerances against machine capabilities.

- Simulation capabilities that allow opportunities to simulate, for example, circuit performance, circuit timing, circuit interaction, design layout, assembly/disassembly, and maintenance in order to reduce the requirement for pilot fabrication as well as physical mockups and also be useful in developing technical documentation and operating and maintenance manuals.

CAM will allow more efficient production and reprocurement by:

- Introducing the ability to recall the complete set of manufacturing data and use it to manufacture exact reproductions on demand -- next week, next year, or even farther in the future -- or to use this capability, which can be of special value to the military, to achieve potentially vastly improved economies in small-lot manufacturing time.

- Providing the ability to monitor a product's quality and conformance to specifications simultaneously with manufacture through "in-process metrology" that measures the accuracy of the machinery, drill bits, cutting devices, etc., during manufacture that will, for example, produce savings in scrap and rework as well as inspection time.

- Achieving the ability to control the manufacturing process to a much greater degree, improving such qualities as consistency, uniformity, and repeatability and allowing scrap, rework, and inspection time to be reduced.

- Transmitting data and information to a central processor that can streamline the ordering, transportation, delivery, and loading of raw materials, and which can begin to provide the means for vast improvements in the economics of manufacturing.

COMPUTER-INTEGRATED MANUFACTURING (CIM)

Many defense and aerospace contractors are implementing -- or have plans to implement -- CIM into their manufacturing organizations. Implementing CIM involves a dramatic change in manufacturing philosophy because the entire organization is affected.

In a traditional plant, like processes and machinery are generally grouped. It takes extra time to move materials and schedule machines. CIM, however, normally allows for flow-through manufacturing, enabling machines to be arranged in sequence by operation. These arrangements are called manufacturing cells. The CIM factory includes a number of independent manufacturing cells, and each of these cells includes the machines needed to produce or assemble a part or product with minimal human intervention.

A machining center that consists of several manufacturing cells is called a flexible manufacturing system (FMS). An FMS normally includes automated material-handling systems, robots, programmable controllers, and direct, numerically controlled machine tools.

The computer plays a dynamic role in the CIM process. Unlike the traditional manufacturing system, CIM is supported by a network of computer systems tied together by a single set of integrated data bases. These data bases can direct manufacturing activities, record results, and maintain accurate data.

For PEP, CIM will permit improvements in producibility planning, primarily through better manufacturing controls of work loading and manufacturing flows. It will also lead to a reduction in manufacturing cycle time.

PEP has great potential. If the technologies discussed in this section are applied successfully, most of the tasks that add up to PEP will be considered automatically as the product is defined. Nonetheless, knowledgeable, interested people with commitment from management are essential. The results of the PEP process are important long after the product is delivered. The way that it was produced and the nature of the documentation are equally important for economic downstream support of the system.

FUNDING AND RESOURCE IMPLICATIONS

Many defense contractors are adopting new "factory-of-the-future" technology to increase their long-range competitive posture and total profitability. The major area of concern for the program manager is that applying CAD/CAM and CIM to his program may not return a short-term benefit; it may, in fact, delay the program. But the potential benefits are so great that the program manager should work some aspects of CAD/CAM and CIM into his program, consistent with his approach to management of information resources. Integrating work from other programs may allow some results while requiring fewer program resources. Finally, taking present contractor capabilities in CAD/CAM and CIM into account during source selection will motivate and reward independent development of these technologies.

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APPENDIX

SOURCE MATERIALS AND RESOURCES AVAILABLE TO THE PROGRAM MANAGER

This is a compilation of source materials and other resources available to the program manager for support in formulating and executing the producibility engineering and planning (PEP) program. Important directives, instructions, and regulations governing PEP are also noted, along with a brief discussion of the more important data items related to PEP.

DOCUMENTS

The following 11 documents are of special value:

1. "Transition of Weapons Systems from Development to Production," Report of Defense Science Board Task Force, Office of the Under Secretary of Defense for Research and Engineering, August 1983.

This summary of the findings of various panels -- on design, test, production, facilities and investment, and management -- lists recommendations for improving and speeding the transition of weapon systems into production. It also suggests "templates" for management of critical industrial processes concerned with the design, test, and manufacture of low-risk products.

2. "Solving the Risk Equation in Transitioning from Development to Production," Defense Science Board Task Force, 25 May 1983.

This document is intended for interim use as a "transition" manual in structuring technically sound programs, assessing their risk, and pointing out areas that need improvement. It is designed to foster disciplined engineering through the use of templates for funding, design, test, production, facilities, and management of an effective, efficient, low-risk program. The material in this document will be included in the following document (number 3).

3. DoD 4245.7-M (DRAFT), "Transition from Development to Production," Under Secretary of Defense for Research and Engineering, publication expected in February 1985.

This manual is intended to assist DoD Components in structuring technically sound programs, assessing their risks, and identifying areas that need corrective action. Selected portions stress the role of electrical and electronic disciplines in improving system effectiveness and productivity.

4. Proceedings of the DoD/Joint Services Production Readiness Reviews Conference, Wright-Patterson Air Force Base, Dayton, Ohio, 19-20 November 1980.

These proceedings include presentations by DoD personnel, exploring ways to make production readiness reviews (PRR) more effective in their contribution to the DoD acquisition process. In future PRRs, more attention should be paid to (1) reducing production costs, (2) determining software readiness, (3) increasing the productivity of Government personnel at private plants, and (4) devising measures of production readiness.

5. Proceedings of DoD, Joint Services, and Industry Producibility Engineering and Planning Conference, Air Force Contract Management Division, Kirtland Air Force Base, New Mexico, 18-19 November 1982.

These are the views of -- and lessons learned by -- DoD and industry personnel responsible for conduct and administration of PEP. The general purpose of the conference was to make the PEP effort a more effective part of the acquisition process. The participants concluded that PEP requires: greater awareness and emphasis by management, dedicated funding and contractual coverage, early interface between design and production engineering, and better communication between Government and industry. Action items developed after the conference are being considered by Government activities. These proceedings include 23 presentations and accompanying narratives prepared by the conference speakers. The document should serve as a valuable desk reference for both DoD and industry.

6. Proceedings of Army/Industry Conference, "Producibility Engineering and Planning (PEP)," Greenville, South Carolina, 30-31 March 1983.

This record of the first DARCOM-sponsored symposium on PEP comprises 15 presentations and accompanying narratives, including views of DoD, senior Army and industry leadership, material headquarters, and major subordinate commands concerning PEP planning, quality, training, and automated manufacturing, as well as implementation of PEP in three major Army programs.

7. "Manufacturing Management Handbook for Program Managers," Second Edition, Defense Systems Management College, July 1984.

This handbook was designed to serve as a desk reference on current manufacturing methods for program and project managers during acquisition of defense systems, particularly during the production phase. The handbook includes discussions of DoD policies, directives, methods and practices -- as well as a list of acronyms and glossary of terms -- applicable to management of the manufacturing effort performed by defense contractors.

8. "Design Guidance for Producibility," Military Handbook (MIL-HDBK-727), Department of Defense, 5 April 1984.

This book provides the design engineer with information to help him reduce or even eliminate design features that would make producibility hard to achieve. It treats the basic concept of producibility and describes the discipline of producibility engineering. The discussion also includes material selection and manufacturing processes of structural and non-structural design components and mechanical assemblies.

9. "System Engineering Management Guide," Defense Systems Management College, Fort Belvoir, VA, Spring 1984.

The main purpose of this guide is to provide a working familiarity with system engineering management. A number of tools and processes have been developed over the years to assist the system engineer in defining

requirements, configuring and sizing the system, managing its development, and verifying the capability of the design. This guide compiles many of them into a general description of techniques in system engineering and related management techniques for use by program management personnel. The guide is based on the tasks defined in Military Standard 499A (MIL-STD-499A) (U.S. Air Force (USAF)), Engineering Management, augmented in areas that have come into prominence since that document was issued. The book is intended mainly for use in the courses at the college and secondarily as a desk reference for program and project management personnel. Written for current and potential DoD program managers who have some familiarity with the basic terms and definitions employed in program offices, the guide is intended to provide the perspective and background data in system engineering needed for effective overall program management. It covers the development of a system from inception to operational deployment and use.

10. "Guide for Transitioning Army Missile Systems from Development to Production," Technical Report RS-81-6, Production Engineering Division, System Engineering Directorate, U.S. Army Missile Laboratory, U.S. Army Missile Command, Redstone Arsenal, Alabama, July 1981.

This guide to the transition process identifies major issues and the measures required. It was written for use by program managers, their staffs, and other elements involved in developing and producing new missile systems. It will be updated as required. The guide includes a chapter on major programs and activities affecting transition, including PEP, and chapters on transition-related activities during the conceptual, validation, full-scale development, and production phases of the acquisition process.

11. "Preparing Weapon Systems for Production: Can We Afford Not To Do It?" Draft of a Proposed Report, GAO Assignment Code 951718, U.S. General Accounting Office, July 1984.

This detailed review of six weapon systems is designed to illuminate some causes of early production problems and outline measures that could help

minimize their occurrence in future programs. The programs reviewed are the Army's Copperhead projectile and Black Hawk helicopter, the Navy's High-Speed Anti-Radiation Missile (HARM) and Tomahawk cruise missile, and the Air Force's F-16 fighter and Air-Launched Cruise Missile (ALCM).

TRAINING AND ORGANIZATIONAL SUPPORT

The Defense Systems Management College provides program management with training in PEP through courses in program management and manufacturing management. The 20-week course in program management, which is designed for mid-level managers, approaches the subject from the program manager's point of view. Instruction is designed to increase the student's ability to manage a defense system acquisition program successfully through functional knowledge, case studies, lessons learned, and a series of interactive decision exercises.

The one-week course in manufacturing management provides a forum in which Government and industry representatives explore contemporary issues. The course includes various considerations -- productivity, producibility, industrial base, labor, and quality compliance that affect planning and design efforts. The course also includes discussions of production readiness reviews, transition from research and development to production, and pre-planned product improvement. The course concentrates on the means for achieving a successful transition from development to production.

The Army Management Engineering Training Activity (AMETA) conducts a three-day course in management and control of PEP at Rock Island Arsenal. It covers: PEP background; PEP in the weapon system life cycle; PEP during design, production planning, and production implementation; and PEP as a management approach. Emphasis is placed on case studies.

Assistance in PEP program definition and implementation can also be obtained through the product engineering support organizations in the Office of the Secretary of Defense (OSD) and the Services. The OSD Product Engineering Support Office (PESO) and the Service PESOs provide checklists and other materials useful in production management.

DIRECTIVES, INSTRUCTIONS, AND REGULATIONS

PEP is governed mainly by DoD Directives 4245.6 and 4245.7, DoD Instruction 5000.38, and their Service implementations. Each is summarized here.

- DoD Directive 4245.6, "Defense Production Management." This Directive updates policy, procedures, and responsibilities for production management in DoD during the acquisition of defense systems and equipment. It is DoD policy to plan for production early in the acquisition process and to integrate acquisition actions to ensure an orderly transition from development to cost-effective rate production.

- DoD Directive 4245.7, "Transition from Development to Production." This Directive consolidates established policy, prescribes procedures, and assigns responsibilities in the application of fundamental engineering and technical disciplines in acquisition programs to expedite the transition from development to production, consistent with DoD Directive 5000.1, "Major Systems Acquisition;" DoD Instruction 5000.2, "Major System Acquisition Procedures;" DoD Directive 5000.3, "Test and Evaluation;" and DoD Directive 4245.6, "Defense Production Management;" and authorizes the publication of DoD 4245.7-M, "Transition from Development to Production." It is DoD policy to ensure that fundamental engineering principles are followed and that relevant technical disciplines are applied in the development and production of defense systems, support equipment, and modifications. The policies and procedures in these Directives shall be supplemented by a formal program of risk evaluation and reduction. Emphasis is to be placed on maintaining program technical balance. Implementation of this policy must be consistent with -- but not subordinate to -- funding, scheduling, and other constraints.

- DoD Instruction 5000.38, "Production Readiness Reviews." This Instruction establishes policy, assigns responsibilities, and states general procedures and guidelines for conducting PRRs of defense systems. The objective of a PRR is to verify that the production design, planning, and associated preparations for a system have progressed to the point where a production commitment can be made without incurring unacceptable risks of breaching thresholds of schedule, performance, cost, or other established criteria. It is the policy of DoD to require a PRR before production begins, including any limited production occurring during FSD. For major systems, an independent assessment of production readiness supported by the findings of the PRR is to be provided to the highest level review body, either the

DSARC, or the Service System Acquisition Review Council ((S)SARC), to substantiate the production recommendation submitted to the Secretary of Defense. A PRR plan is to be developed and approved by the sponsoring DoD Component.

Further guidance, complementary to DoD Instruction 5000.2, has been distributed through Defense Acquisition Circular (DAC) Number 76-43 (Item I), "Major Defense System Acquisition Policies and Procedures." It includes principles of acquisition management and system design pertinent to PEP, especially for production planning and contractor's production capability. In particular, it says:

> Contractor's Production Capability. The capability of both prime and major subcoutractors to produce the end item in the required quantities and on time must be a prime consideration in the full scale development phase of defense systems. Production capability encompasses plant, production equipment, management and control systems, personnel, past performance, and producibility of the design. Production engineering must be considered throughout the evolution of the design and an assessment of the producibility of the design shall be included in the design reviews. Funds allocated to producibility engineering and planning (PEP) will not be utilized to accomplish other full scale development efforts until PEP objectives are met to ensure cost effective fabrication, assembly, inspection, and testing of end items.

In addition, the military standard on production management, MIL-STD-1528, describes: the scope of DoD production management; requirements for the production management system, production engineering, production planning, production surveillance, control of subcontractors and vendors, facilities, and tooling and test equipment; and specific requirements for the production plan, production capability estimate, production feasibility assessments, PRR, and reports by the contractor on production progress.

The Army's approach to PEP is specifically outlined in DARCOM (AMC) Regulation 70-6, to be implemented consistent with Army Regulation 70-1.

DARCOM Regulation 70-6 prescribes policy, general procedures, and responsibilities for conducting PEP for Army systems and materiel:

- Contracts with industry shall include commitments and provisions to assure from the outset that a cooperative industry/Government team-player environment is established in order to initiate, conduct, and complete PEP on an adequate and timely basis.

- During the concept exploration phase, the production feasibility of candidate system concepts shall be addressed, perceived areas of production risk identified, and the manufacturing technology needed to reduce production risk to acceptable levels identified.

- During the demonstration and validation phase, producibility analyses of the design approaches shall be performed, manufacturing technology deficiencies addressed, and production risks evaluated for acceptability. Requirements for long-lead procurements and limited production shall be identified and evaluated. Plans shall be formulated for achieving producibility and unit cost goals. Resources to adequately perform PEP should be identified during this phase.

- Throughout full-scale development, design and production engineering for production planning shall be accomplished, to include development and validation of a complete technical data package including specification and prove-out of the required production resources. Producibility of the design, utilizing cost-effective manufacturing methods and processes, shall be attained. Production risks shall be reduced to acceptable levels and the state of production readiness achieved prior to a production decision. Plans and provisions for accomplishing additional cost reduction during production shall be formulated.

The Air Force's approach to PEP is conducted under Air Force Regulation (AFR) 800-9, Manufacturing Management Policy for Air Force Contracts, which states the Air Force's manufacturing management policy for acquisition and contract support of major systems, subsystems, and equipment and all other programs that may involve manufacturing. To keep costs down, it calls for tailoring implementing procedures to individual program or project requirements and selective applications. Air Force Manufacturing Management Policy states:

> The goal of this policy is to efficiently and effectively manufacture and support Air Force systems and to reduce cost and leadtime by the management of production resources. It is imperative that this goal be considered throughout the life cycle of our development and acquisition programs with special emphasis on the planning and

> early development efforts. Through our program structure, we will ensure that production resources to be used are modern and cost effective. We will develop a plan for producing and supporting the system, for production surge and industrial mobilization, and for the use of available tools to aggressively manage the plan. At Milestone III, our completed plan will be one of the bases for production decision. At program management responsibility transfer (PMRT), our plan will detail the required contractual supportability including post-production support planning.

The policy is further implemented by Air Force Systems Command Regulation (AFSCR) 800-9, Manufacturing Management. The Navy's approach to PEP is reflected in Naval Material Command (NAVMAT) Instruction 4855.10, Contract Manufacturing Requirements. An instruction on transition from development to production is in preparation.

PEP-RELATED DATA ITEM DESCRIPTIONS (DIDs)

The Acquisition Management Systems and Data Requirements Control List (AMSDL), DoD 5000.19-L, Volume II, is authorized by DoD Directive 5000.19, "Policies for the Management and Control of Information Requirements," 12 March 1976. The AMSDL identifies those acquisition management systems source documents (Rules Documents) and related DIDs (Information Collection Requests) that have been approved for use in defense contracts by the Office of Management and Budget (OMB) under the authority granted by Public Law 96-511, Paperwork Reduction Act of 1980.

Within the AMSDL (as of 31 July 1983) there are 44 DIDs (38 production, 6 manufacturing) listed under production or manufacturing. Twenty-four (21 production and 3 manufacturing) are generally applicable to PEP. Nine of them are under review for possible revision or cancellation (indicated as UDI rather than DI).

The nine DIDs that mean most to PEP are:

- DI-E-1123, (Army) Production Engineering Study. A production engineering study should be made for every new item, new weapon, or weapon system to determine whether the item can be produced economically to

the specified drawing dimensions and tolerances with conventional machine tool equipment and within the limits of the cost estimate. The study is to indicate corrective action to be taken on the drawings and other technical documents to assure a practical and feasible manufacturing process.

- DI-P-1604, (Army) Manufacturing Methods Report. The Manufacturing Methods Report details new manufacturing methods, processes, and techniques in areas where the existing state of the art does not meet military needs.

- DI-P-1612A, (Army) Production Plan. The plan delineates proposed and current production plans to produce acceptable items on schedule at optimal cost. The plan is used in evaluating and monitoring proposed and current production.

- DI-P-1614, (Army) Description of Manufacture. This compilation of technical data and information necessary for manufacturing or controlling the manufacture of a munitions configuration item or component, encompasses the data and information defining equipment, tooling, process technologies, line layout, flow charts, and photographs. The complete program is used in addition to a TDP to help new or supplemental manufacturers to support the mobilization base, or for international logistics purposes.

- DI-P-3460A, (USAF) Manufacturing Plan. This plan permits the buying activity and contract administration office (1) to conduct an evaluation of the contractor's management systems, producibility plan, make-or-buy proposal, and planning and manufacturing capability in support of the development/manufacturing/testing efforts associated with a proposed program, and (2) to assess and maintain surveillance over the contractor's conformance to those plans.

- DI-E-7060, (DoD) Numerical Control Data for Manufacture. Numerical control data is used for manufacture by conventional or numerically controlled machines or other variable-programmed automated industrial processes that use punched tape, card, and/or magnetic tape.

- UDI-S-21078, (Navy) Diagrams, Engineering, & Production Event/Flow. These flow diagrams will be used to establish the activities that will develop source data elements as prime inputs to a contractor data system.

- UDI-P-20236D, (Navy) Follow-On Production & Facilities Plan. This plan defines methods and facilities for producing, assembling, testing, and accepting the system.

- UDI-P-20414, (Navy) Production and Facilities Plan. The plan provides overall production and facilities plans for pilot production.

The last three DIDs are under review for possible revision or cancellation.

Ten additional DIDs are being prepared by AMETA to complement the PEP program.

The following 15 DIDs are also applicable to PEP:

- DI-F-1203, Budgetary Cost Estimate for Production Program
- DI-F-1212, Contractor's Item Production Cost Statement (Unit Cost)
- DI-P-1613, List of Special Production Tooling
- DI-T-1903, Production/Acceptance Inspection Procedures
- DI-P-3455, Production Analysis Report
- DI-T-5156C, Quality Status Report of Production Testing
- DI-P-5401A, Production and Delivery Report
- DI-P-7119, Post Production Support Plan
- DI-A-16241B, Agenda/Report for Production Progress Conferences
- UDI-P-20168, Production Inspection Equipment (PIE) and Hard Tooling Acquisition Plan
- UDI-R-20403C, Production Inspection Plan
- UDI-T-20593, Production Test Equipment Design Proposals
- UDI-T-21365A, Production Acceptance Test Specification
- UDI-T-23044, Production and Production Control Test Condition Verification Plan
- UDI-T-23921, Production Inspection Test Procedures